Journal of the Minnesota Academy of Science

Volume 42 | Number 2 Article 3

1976

Chlorofluorocarbon Effects on Cardiac, Pulmonary, and Respiratory Patients

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ABSTRACT- Research results from studies of the physiological effects of aerosal propellants on animals and people are summarized. The papers selected for this summary were published between 1968 and 1975. Effects of the 15 chlorofluorocarbons used as propellants have been recorded on the cardiac, pulmonary and respiratory functions of a number of animal species as well as man. The fifteen propellants have been classified into four groups on the basis of their degree of toxicity. Fluorocarbon 11, the most frequently used propellant, is in group 1, the most toxic. The relative toxicity of each of the 14 other propellants compared with FC 11 is reported. On the basis of these results, it is suggested that the two problems created by chlorofluorocarbon propellants, potential ozone depletion and adverse psychological effects, be considered simultaneously, since limiting the exposure would tend to decrease the risk either to the ozone layer and to people.

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The purpose of this paper is to a) summarize research on chlorofluorocarbons used as aerosol propellants, b) disseminate this information to enhance awareness of the potential for harm to the human body from chlorofluorocarbon propellant exposure and c) suggest that the two main hazards from these compounds 1) their adverse effects on cardiac, pulmonary and respiratory function and 2) their potential for diminishing the ozone layer around our biosphere be considered simultaneously and seriously by decision makers of the world.

Interest in chlorofluorocarbon propellants is an outgrowth from a personal experience of this author. In 1971, I noticed abnormalities in my heart rhythm and in my breathing pattern. When I stopped the use of a hair spray, these abnormalities disappeared. In attempting to find out what there was in hair spray which could produce those symptoms, it was not possible to get desired information from the label because producers of aerosol products were not required at that time to list the contents. I then wrote to the Drug Administration (FDA) in Washington, stating: "The possibility exists that I could have unique sensitivity to one of the components . . . However, my (cardiac and respiratory) symptoms were severe enough to have caused considerable concern, and I would like to spare others who might be similarly unnecessarily affected." The response was that, although the product mentionaed had not been analyzed, typical sprays contain a Freon propellant, alcohol, and a plastic film former.

"It is possible," the reply noted, "that some individuals are abnormally sensitive to Freon, however, evidence on this point is quite hard to obtain. We are sponsoring research in animals on various effects of these substances and will take appropriate action if any definite hazard appears."

A personal effort to find out more about Freons was made and a search of the literature about their physiological effects, was then undertaken.

Freons are trade names for that group of chemicals which are generically the halogenated hydrocarbons, more specifically designated as chlorofluorocarbons. Compounds containing fluorine are also called fluoroalkanes. A combination lettering and numbering system is sometimes used for identification, and the farthest right digit refers to the number of fluorine atoms. FC 12 stands for fluorocarbon 12, which is dichlorodifluoromethane.

Tests on the chlorofluorocarbons in the 1950's showed that they were chemically inert and relatively non-toxic by the standard tests used. The conclusion was that these compounds would be safe to use as propellants in spray dispensers. Many chlorofluorocarbons are gases which can be liquified at low pressure. When an inexpensive release valve was designed, a new way for dispersing many compounds became possible.

In the 1960's startling and appalling incidents of sudden death among healthy young people were attributed to inhaling vapors from various products including the fluoroalkanes and glues. Abuse of these substances was indicated, but the number of deaths was disturbing and suggested that a more thorough evaluation of physiological effects was needed. Clinical scientists began systematic study of aerosol propellants in the 1970's under controlled laboratory conditions. A number of investigators suspected that Freon compounds were in some way toxic to the heart.

Death rates among people with asthma also drew attention in England and Wales between 1951 and 1964. Speizer in (1968) demonstrated a three fold increase in mortality rates at all ages from 5 to 34, with the greatest increase (eight fold) in the 10-14 year age span of the asthma group. He suggested that the increase might be due to the increased availability of medications propelled by aerosols. Speizer then studied the records of 177 asthmatic people who had died in Britain and Wales. Although he found that 146 of 174 (84 percent) had used aerosol-dispensed medication, he concluded that the evidence from the records was not sufficient to incriminate aerosols as the cause of death.

The report of the increased death rate among people with asthma stimulated some clinical scientists to study the effects of chlorofluorocarbon propellants on lung

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function. Other investigators were interested in learning whether the propellant material was absorbed in the blood. Dollery (1970) and colleagues were among the first to demonstrate that these propellants could be detected in the bloodstream after having been inhaled. Paterson and co-workers (1971) confirmed the preliminary findings of Dollery. They measured blood levels of two of the most commonly used propellants, Freon 11 and Freon 12, in twelve asthmatic patients and three healthy control subjects. After the subjects had taken only 2 breaths from a dispenser, Paterson found peak blood levels ranging from 0.13 to 2.60 micrograms of FC 11 per milliliter of blood. He also determined the time this substance remained in the blood, and found that the level of FC 11 dropped to half the peak level in times ranging from 18 seconds to 90 seconds. When Paterson could not detect FC 12 in the blood, he concluded that this very volatile compound must have disappeared before it could be measured.

Taylor and Harris (1970) found that fluoroalkane propellants changed the heart function in mice, dogs, and rats. On the 34 mice, the compounds produced abnormalities in electrocardiograms and slowed the heart rate. They reported that sensitization of the heart occurred rapidly, was long-lasting, and fatal. These authors were the first to suggest that the effects of chlorofluorocarbon propellants would show up in different ways in different species, speeding the heart rates in some, slowing it in others, and cause changes in heart muscle contractility. They pointed out that in the earlier toxicity studies investigators had not used the electrocardiograph as a monitor, and thereby missed detection of cardiac arrhythmia. The authors had used the "asphuxia challenge" in their experiments and felt that it was important to use this to simulate conditions under which the young people had died. Alluding to the cases of sudden death among young healthy people, Taylor and Harris concluded "Since three breaths of propellant sensitize mice immediately and for hours thereafter to the cardiotoxic effects of asphyxia, the amounts of propellant deliberately inhaled by these youths seem adequate, particularly when combined with asphyxia, to cause fatal cardiac toxicity."

Drs. Flower and Horan (1972) studied sixteen dogs which they had breathe chlorofluorocarbon propellants. They used FC 11 and FC 12 as well as glue. They maintained normal arterial oxygen tension with a respirator because they wanted to find out whether the heart arrhythmias reported by Taylor and Harris when they gave an asphyxia challenge to mice were produced or made worse by the combination of fluorocarbon plus hypoxia. Flowers and Horan recorded electrocardiograms and found the same pattern of disturbed heart rhythm as were observed by Taylor and Harris. They gave 100 percent oxygen to six animals. The results were still the same--slowing of the heart rate and disturbances of the rhythm. In some of the experiments, fluorocarbon administration was stopped as soon as a change in heart rhythm was noted. In spite of this, the animals still died.

Bernstein (1972) focused on the medical hazards of aerosols. Reviewing the techniques for studying a respiratory problem, he indicated that while inhalation tests can give important information, they should be done only under carefully controlled conditions.

Harris (1973) summarizing research findings, stated: "Contrary to their reputation as being inert, aerosol fluoroalkane propellant gases (Freons) are rapidly acting and potent cardiac toxins." He indicated that we still need to learn how these gases produce their effects on the cardiovascular system. He suggested measuring blood levels of the chlorofluorocarbons in people who frequently use aerosol products. He further suggested a study to find out whether people with known diseases might be more susceptable or have lower tolerance for the toxic effects of the chlorofluorocarbons. When his work was criticized by investigators who had been unable to demonstrate cardiotoxicity, Harris (1973) pointed out that those investigators had not done the same kind of experiment that he had done.

Zuzkin and colleagues (1974) reported that when they exposed 20 healthy subjects, 14 men and six women, to three different hair sprays for 20 seconds, they could demonstrate a decrease in expiratory flow volume curves. This decrease, according to the authors, indicates a constriction of the small airways in the lungs. They state ". . . we believe that our observation should lead to increased concern about the respiratory effects of hair sprays and other aerosol consumer products."

Nicholas (1974) was concerned about the Freon propellants used in bronchodilators, observing that these compounds were neither inert nor nontoxic.

Graham (1974) expressed his concern about the safety of an aerosol product used to speed up the process of freezing tissues for microscopic study.

Speizer (1975) reported arrhythmias associated with fluorocarbon exposure in young doctors in training at the pathology department of a hospital. Fluorocarbon 22 was being used for rapid freezing of tissue specimens. Doctors in the second and third year of their training (not in the first year) commented on being aware of arrhythmias. When exercise electrocardiograms were taken, arrhythmias were demonstrated. While arrhythmias can occur among otherwise normal people, fewer numbers of people not exposed to fluorocarbon propellants in that hospital had heart irregularity than the exposed personnel. Speizer concluded with a recommendation: "From the data presented, we believe that it would be prudent for hospital workers using fluorocarbons in their work, as well as other industrial groups using large quantities of aerosol propellant substances, to reassess their needs and seek suitable substitutes."

Aviado and associates, who in 1974 had published some of the results of research, continued in 1975 to pulbish results of massive investigations on the effects of chlorofluorocarbons. These investigators, on contract with the FDA, have collected hard data on the psysiological effects of the 15 chlorofluorocarbons which are used as propellants. Different animal species were used in order not to miss any important effects these compounds might have. On the basis of his data and those of other investigators on the effects of the fluoroalkane propellants on the pulmonary, respiratory and cardiac functions, Aviado has classified the 15 chlorofluorocarbons into 4 groups:

1) - Low pressure propellants of high toxicity.

According to Aviado, trichlorofluoromethane, FC 11,

is the most widely used propellant. FC 11 is in this group. The other propellants have all been compared with FC 11.

2) - Low pressure propellants of intermediate toxicity.

3) - High pressure propellants of intermediate toxicity.

The second most commonly used fluoroalkane propellant is said to be FC 12. It is in this group.

4) - High pressure propellants of low toxicity.

For the compounds in each of the four groups, the data have been organized into tables giving the animal species and investigator. Each propellant is compared with FC 11 with respect to acute inhalational toxicity, chronic inhalational toxicity, acute cardiovascular toxicity and acute bronchopulmonary toxicity.

This comparative study by Aviado and colleagues has shown the following effects of the fluorocarbons used as propellants:

Inhalations of propellants produces cardiac arrhythmia. In some animals, the propellants change heart rate, speeding it up in some and slowing it in others, as Harris had predicted. In the monkey, all the propellants except one interfered with the ability of the heart muscle to contract. The propellants cause hypotension (lowering of the blood pressure). They produce different breathing patterns – some depressing respiration and some stimulating it. They bring about a variety of changes in the lung function, depending upon the animal. Some dilate the bronchioles in one species and constrict the bronchioles in another. Aviado indicates that more study of lung function is necessary.

On the basis of published research results, it is quite apparent that the chlorofluorocarbons produce alterations in physiological functions of healthy animals and people. Aviado warns that since half of the propellants tested brought about an increase in pulse rate, exposure to any of those would be dangerous to an individual who has coronary heart disease. One might add that chlorofluorocarbon induced arrhythmias would not be helpful to a person with other cardiac problems either. Aviado also points out that the effect of the fluoroalkane propellants on lung function is important information needed for understanding of the possible harm these compounds might cause a person whose lung function is already decreased by disease or by accident.

The classification of the fluoroalkanes which Aviado has made will be helpful when labeling of aerosols has become universal.

Concern about possible ozone depletion is on the increase. Production of chlorofluorocarbons has reached 800 million pounds per year in this country. Of the 800 million pounds, 50 percent is used as propellants for products packaged in aerosol cans. Total world production has rea ched 1.7 billion pounds (Science News).

With the information from the literature considered in this review, it is apparent that we not only need be concerned about the possible depletion of the ozone layer (by the chlorine released when these compounds are broken down) but we also must be concerned about the adverse effects the fluorocarbons have been shown to have on cardiac, pulmonary and respiratory functions in healthy animals and people. We should consider that these adverse effects might be even more adverse to these functions in people with heart and lung disease.

By reducing all unnecessary exposure to chlorofluorocarbon propellants, we would be removing the double jeopardy – jeopardy to the heart and lung functions of people and jeopardy to the ozone layer.

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